Computer Networks

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Local Area Network Overview

LAN

- A local area network (LAN) is a collection of devices connected together in one physical location, such as a building, office, or home.

- A LAN can be small or large, ranging from a home network with one user to an enterprise network with thousands of users and devices in an office or school.

- Regardless of size, a LAN's single defining characteristic is that it connects devices that are in a single, limited area.

LAN Applications (1)

- Personal computer LANs
  - Cover all the needs of a typical organization/office
  - Low cost
  - Limited data rate
- Back end networks
  - Interconnecting large systems (mainframes and large storage devices)
    - High data rate
    - High speed interface
    - Distributed access
    - Limited distance
   - Limited number of devices

LAN Applications (2)

- Storage Area Networks
  - Separate network handling storage needs
  - Detaches storage tasks from specific servers
  - Shared storage facility across high-speed network
  - Hard disks, tape libraries, CD arrays
  - Improved client-server storage access
- High speed office networks
  - To take care of the new applications evolved in the office environment
- Backbone LANs (The Trunks)
  - Interconnect low speed local LANs
  - Drawbacks to a single LAN strategy:
    - Reliability
    - Capacity
    - Cost

Storage Area Networks
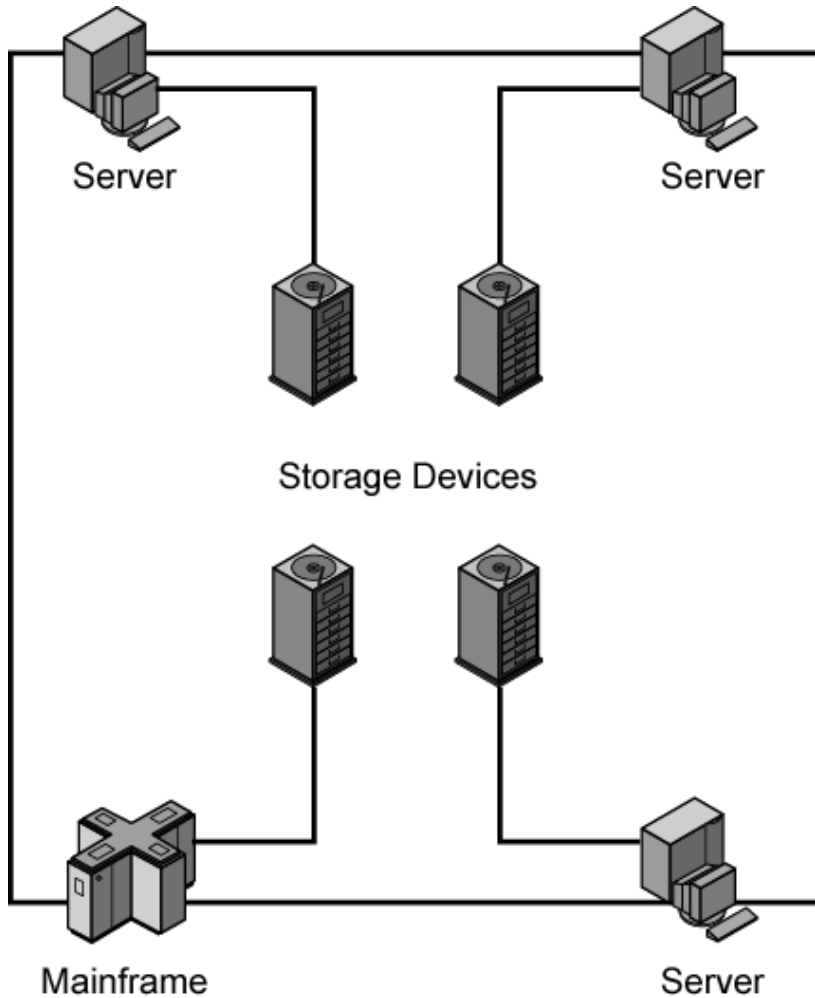
(a) Server-based storage
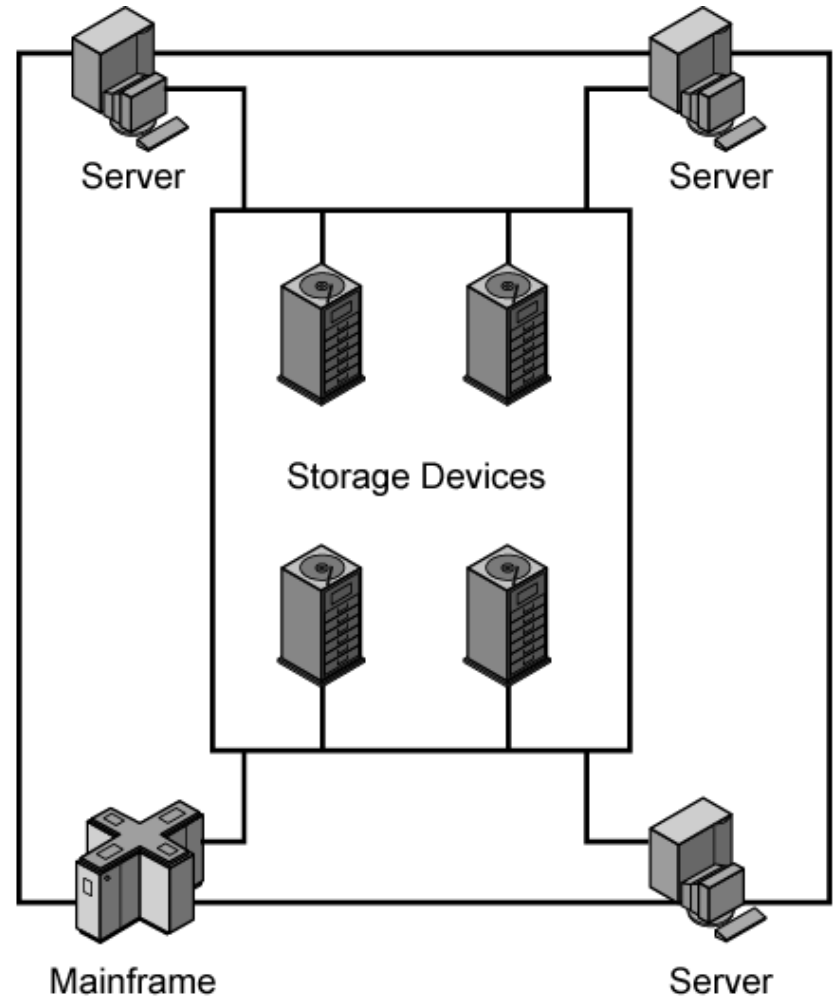
(b) Storage area network

LAN Architecture

- Topologies
- Transmission Medium
- Network Devices

What is Topology?

- Network topology defines the structure of the network and tells us how all the components are interconnected to each other.

- The topology term refers to both the physical and logical layout of a network.

- **Physical Topology:** How the devices are physicaly connected. Here we talk about the physical routes and cables.

- **Logical Topology:** How the devices appear to be connected to each other. Here we talk about the data flow and communication.

Topologies

- Tree Topology
- Bus Topology
  - Special case of tree
    - One trunk, no branches
- Ring Topology
- Star Topology
- Mesh Topology
- Hybrid Topology

LAN Topologies

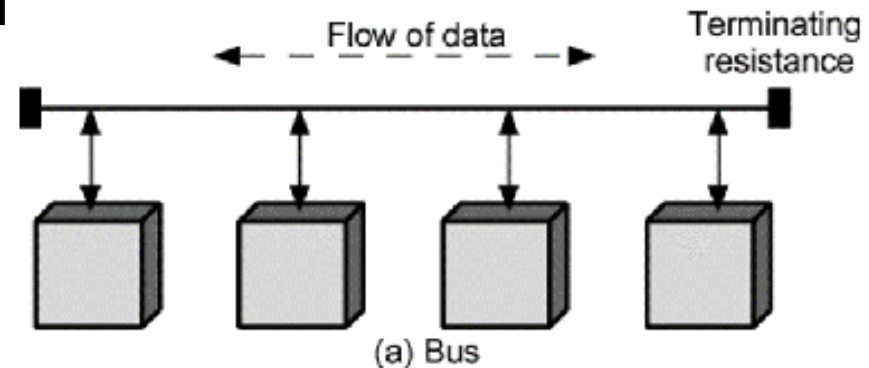(a) Bus

(b) Tree

(c) Ring

(d) Star
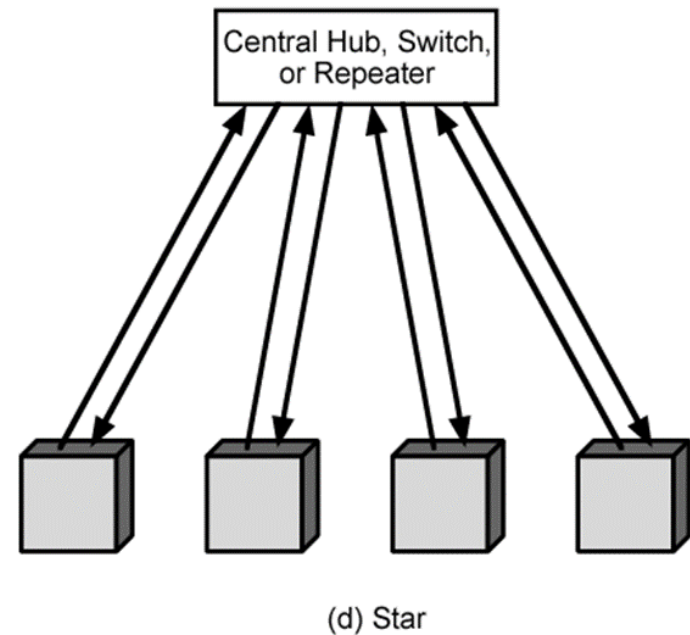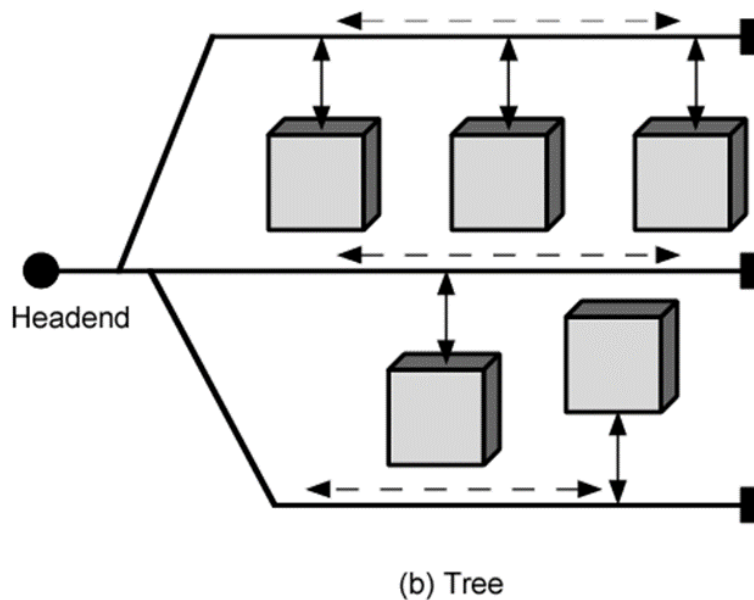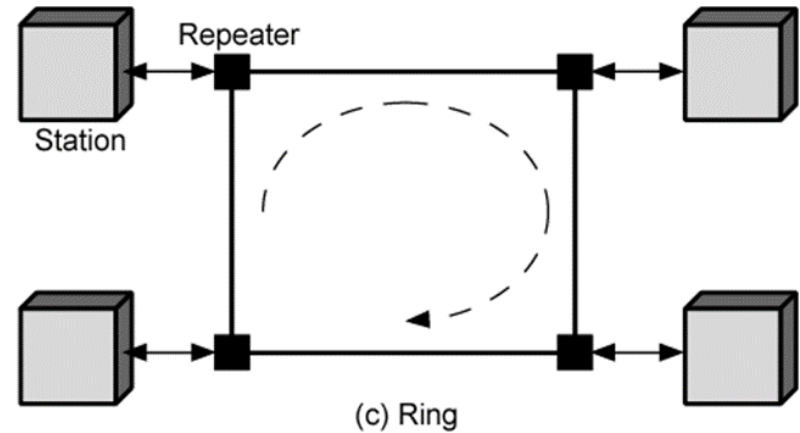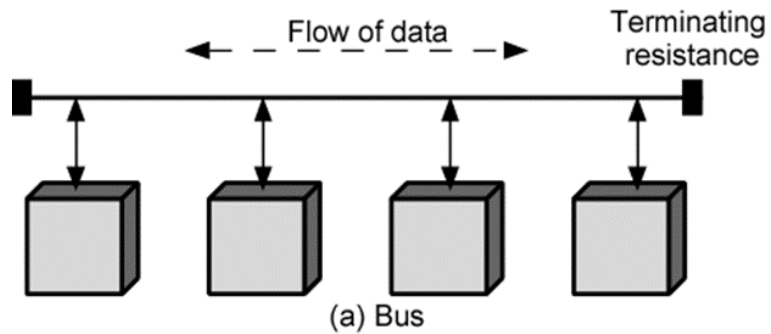
Point to Point Topology

- Point to point is a simple topology that directly links two nodes and reserves the entire bandwidth of the connection for them to communicate with one another.

- A major disadvantage of this network is that there can only be a maximum of two nodes.

Bus and Tree

- The bus topology is designed in such a way that all the stations are connected through a single cable known as a backbone cable.

- Transmission propagates throughout medium

- Heard by all stations
  - Need to identify target station
    - Each station has unique address

- Full duplex connection
  - Allows for transmission and reception

- Need to regulate transmission
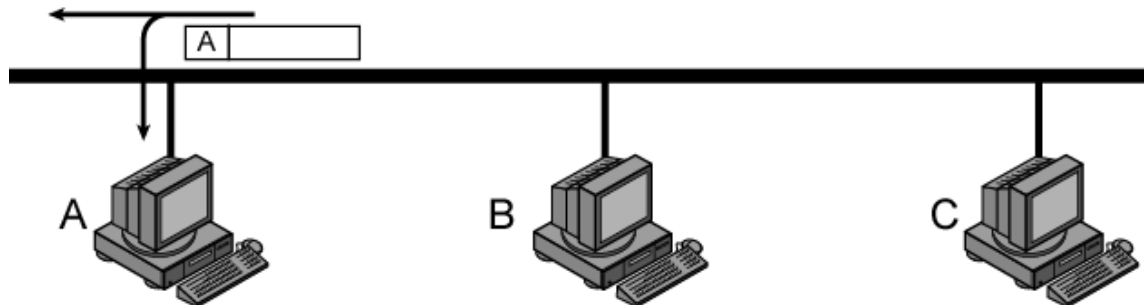 - To avoid collisions

Headend

(b) Tree

Flow of data

Terminating resistance
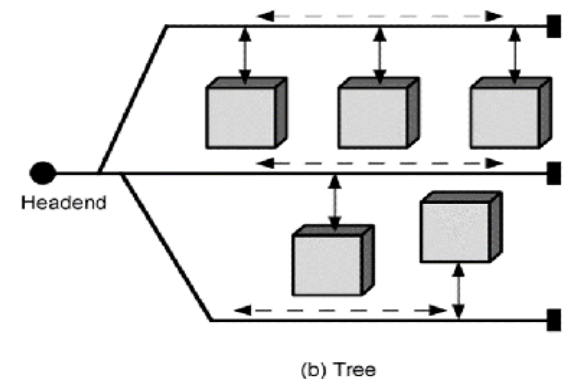
(a) Bus

Frame Transmission on Bus LAN
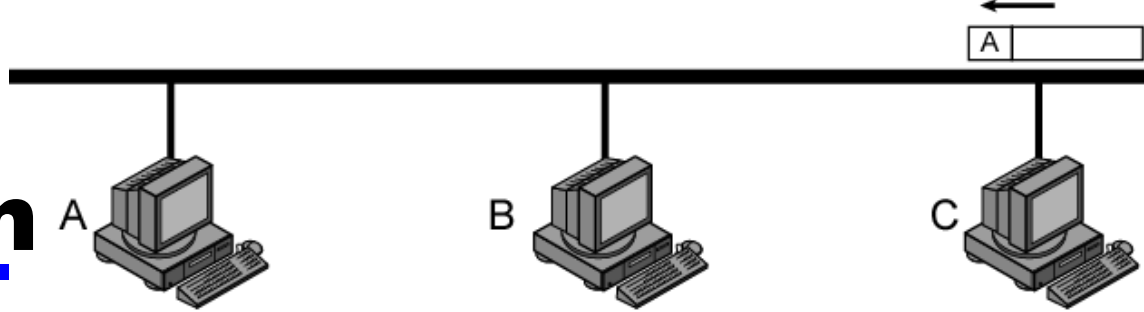
C transmits frame addressed to A
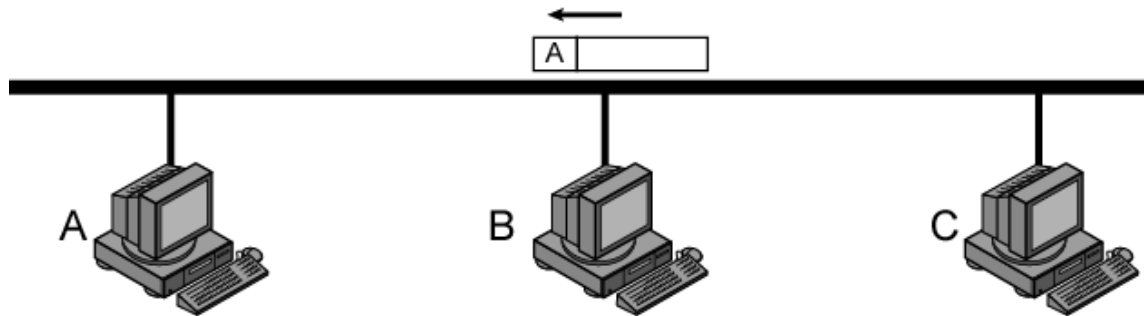
Frame is not addressed to B; B ignores it

A copies frame as it goes by

Ring Topology

- Ring topology is like a bus topology, but with connected ends.
- Repeaters joined by point to point links
  - Receive data on one link and retransmit on another
  - Links unidirectional
  - Stations attach to repeaters
- Data in frames
  - Circulate past all stations
  - Destination recognizes address and copies frame
  - Frame circulates back to source where it is removed
- Media access control determines when station can insert frame
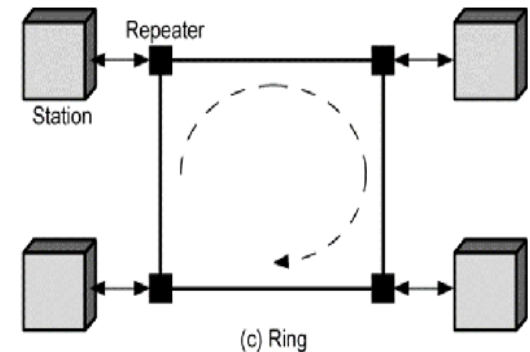
Frame Transmission Ring LAN

(a) C transmits frame addressed to A

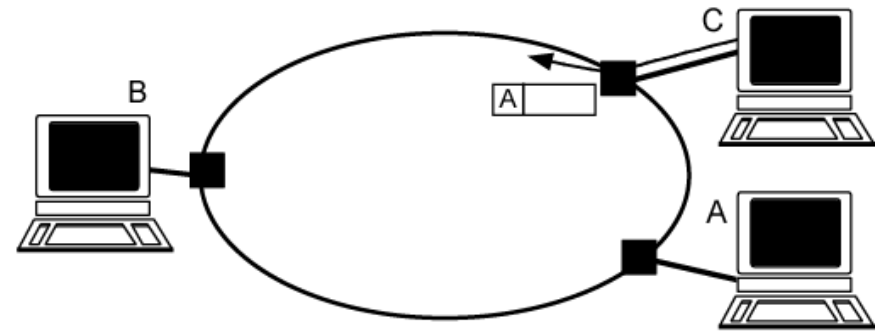(b) Frame is not addressed to B; B ignores it
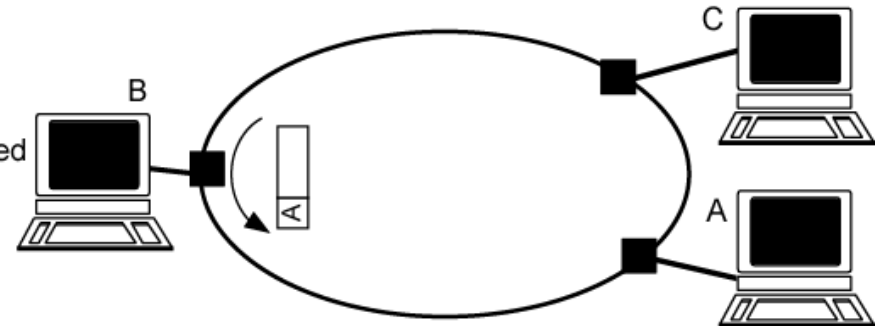
(c) A copies frame as it goes by
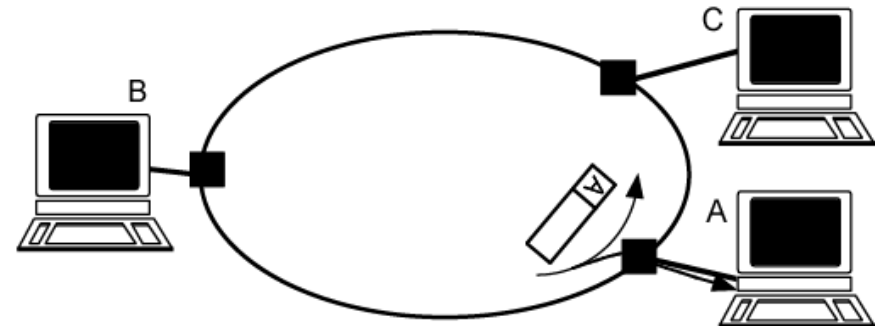
(d) C absorbs returning frame
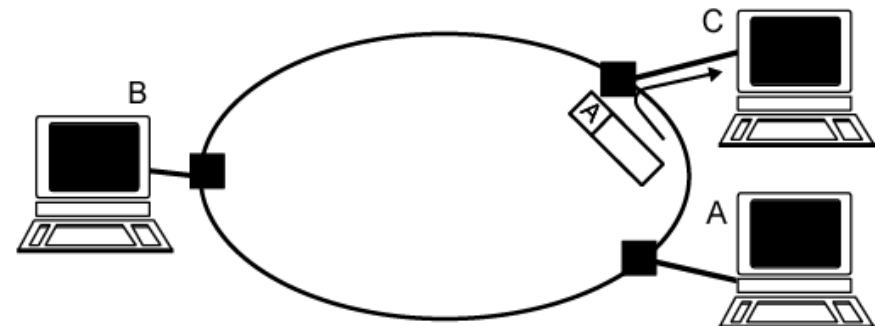
Star Topology

- Each station connected directly to central node
  - Usually via two point to point links
- Central node can broadcast
  - Physical star, logical bus
  - Only one station can transmit at a time
- Central node can act as frame switch

Central Hub, Switch, or Repeater
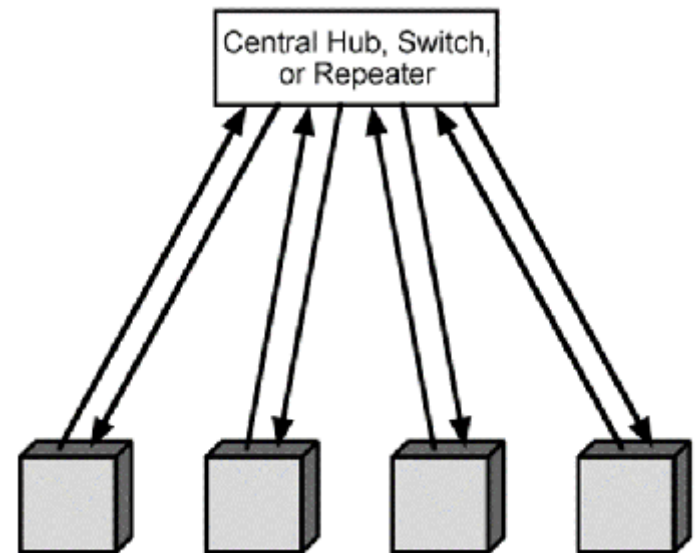
(d) Star

Mesh Topology

- The mesh topology has a unique network design in which each computer on the network connects to every other.
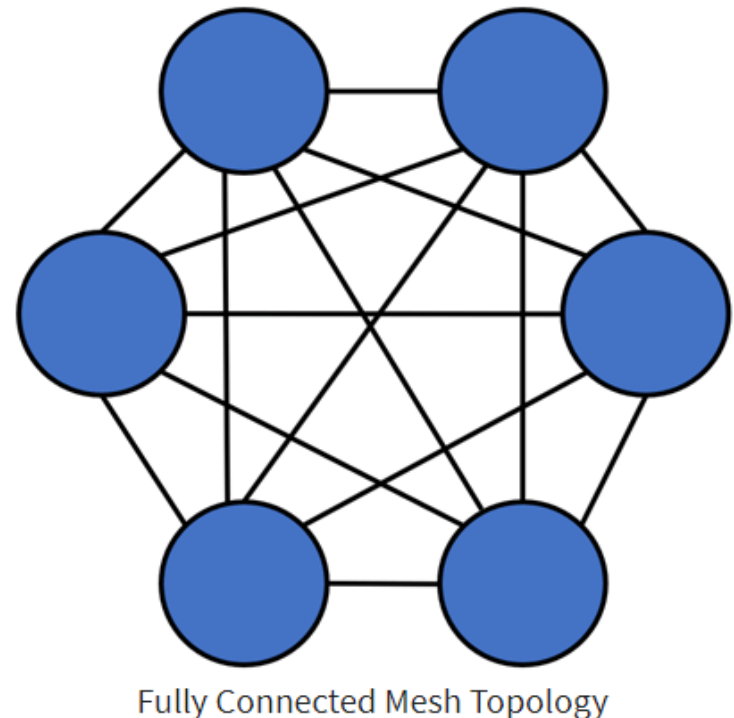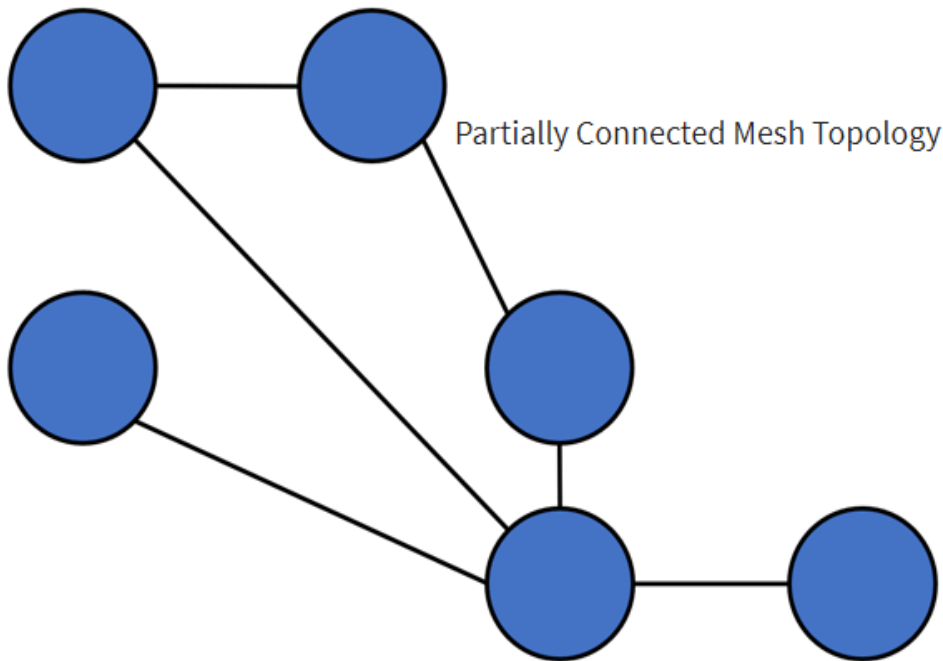
Partially Connected Mesh Topology

Fully Connected Mesh Topology

Hybrid Topology

- Here two or more different topologies are integrated or combined to lay out a network. In layman's terms, hybrid topology is the combination of two or more networks.
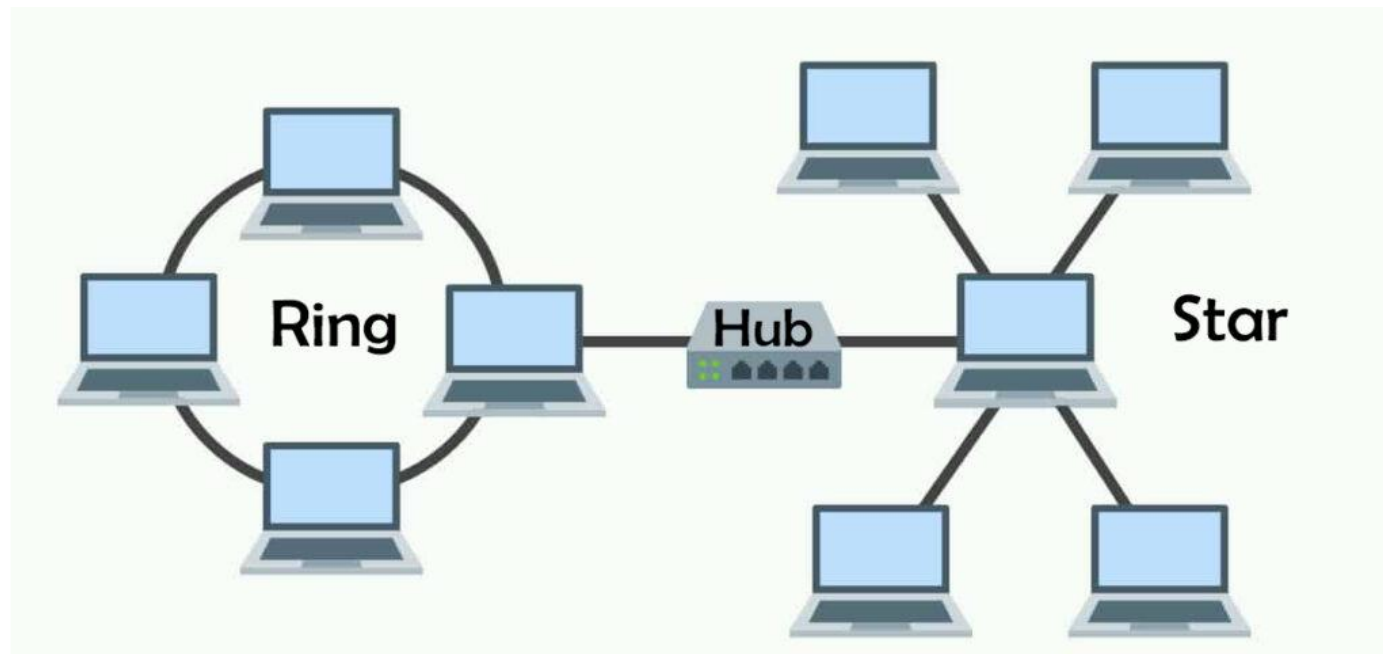
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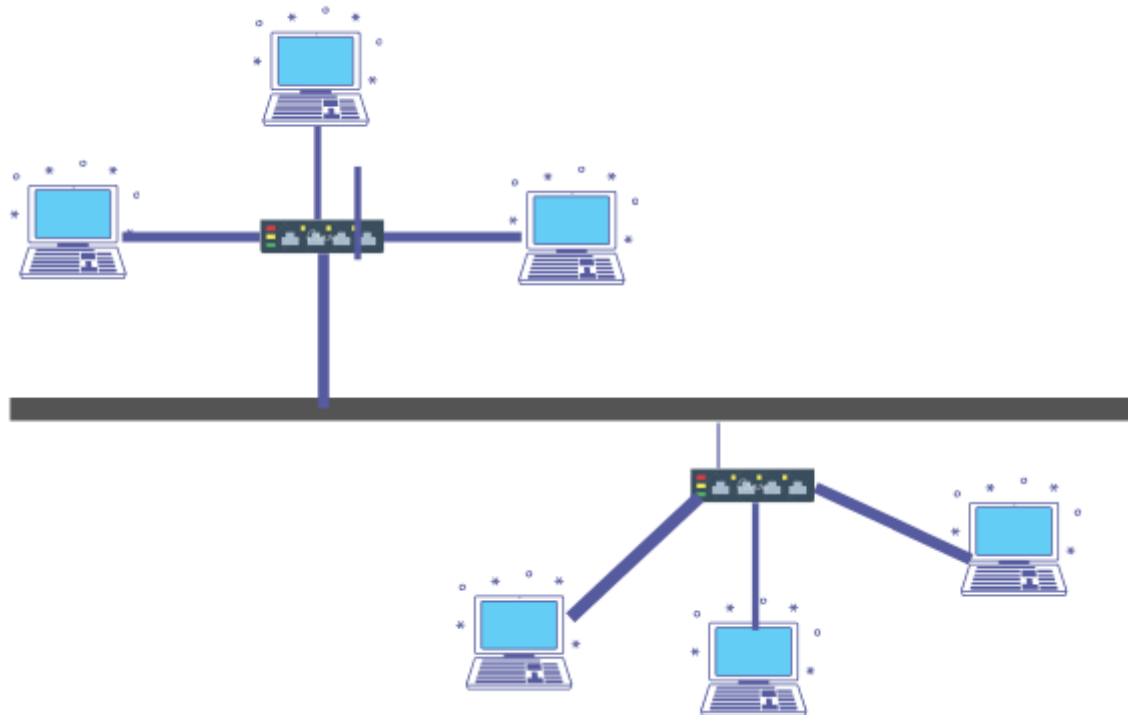
Choice of Topology

- Budget
- Ease of Implementation
- Size of Network
- Reliability
- Protocols
- Expandability
- Performance
- Needs considering in context of:
  - Medium
  - Wiring layout
  - Access control

Transmission Media

- Transmission media is a communication channel that carries the information from the sender to the receiver. Data is transmitted through the electromagnetic signals.

- It is a physical path between transmitter and receiver in data communication.

- In a copper-based network, the bits in the form of electrical signals.

- In a fibre based network, the bits in the form of light pulses.

Classification Of Transmission Media
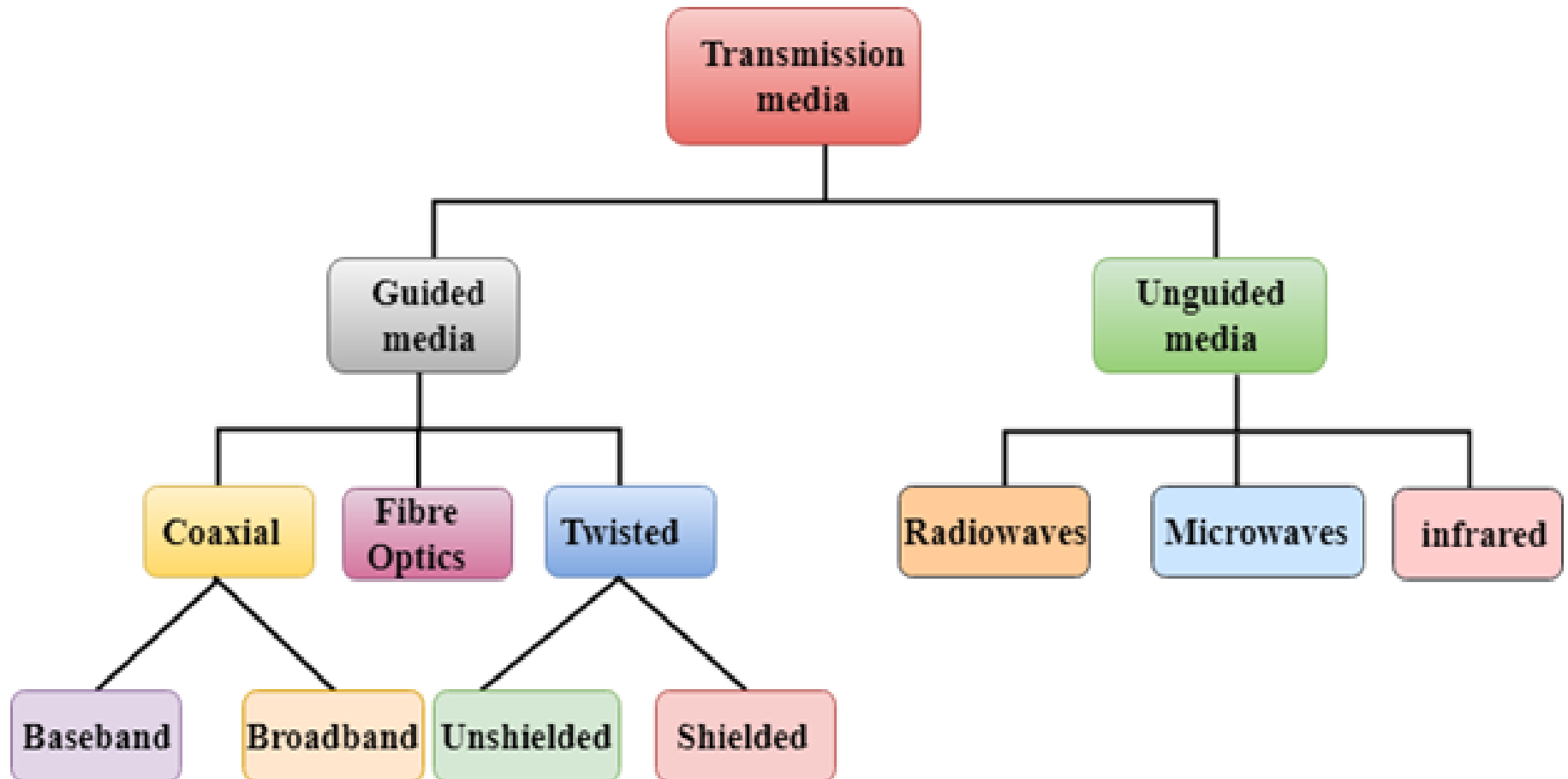
Guided and Unguided Media

- **Guided Media**
  - It is defined as the physical medium through which the signals are transmitted. It is also known as Bounded media.

- **Unguided Media**
  - An unguided transmission transmits the electromagnetic waves without using any physical medium. Therefore it is also known as wireless transmission.
  - In unguided media, air is the media through which the electromagnetic energy can flow easily.

Twisted Pair

— Pair of cables twisted with each other

— Cheap and Easy to Install

— Voice grade cable (0 to 3.5KHz)

— Didn't scale for fast LANs

— Not used in bus LANs now

UTP Cable

STP Cable
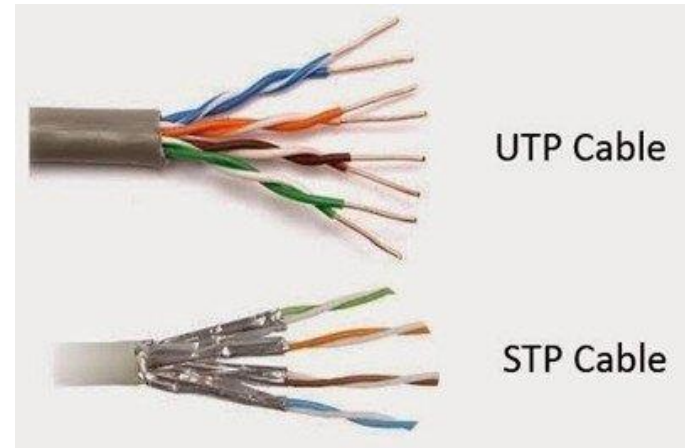
Jacket   Twisted Pair   Bare Wire

Unshielded Twisted Pair

- An unshielded twisted pair is widely used in telecommunication.
  - —Category 1: Category 1 is used for telephone lines that have low-speed data.
  - —Category 2: It can support upto 4Mbps.
  - —Category 3: It can support upto 16Mbps.
  - —Category 4: It can support upto 20Mbps.
  - —Category 5: It can support upto 200Mbps.
  - —Category 6: It can support upto 1 to 10 Gbps.
- Can be used for high-speed LAN but with limited distance

Shielded Twisted Pair

- A shielded twisted pair is a cable that contains the mesh surrounding the wire that allows the higher transmission rate.

- It has higher capacity/datarate as compared to unshielded twisted pair cable.

- It is more expensive as compared to UTP and coaxial cable.

- It has a higher attenuation rate.

Coaxial Cable

- Coaxial cable is very commonly used transmission media, for example, TV wire is usually a coaxial cable.

- The name of the cable is coaxial as it contains two conductors parallel to each other.

- It has a higher frequency as compared to Twisted pair cable.

- The inner conductor of the coaxial cable is made up of copper, and the outer conductor is made up of copper mesh.

- The inner core is responsible for the data transferring whereas the copper mesh prevents from the EMI(Electromagnetic interference).

Coaxial Cable

plastic jacket

dielectric insulator

metallic shield

centre core
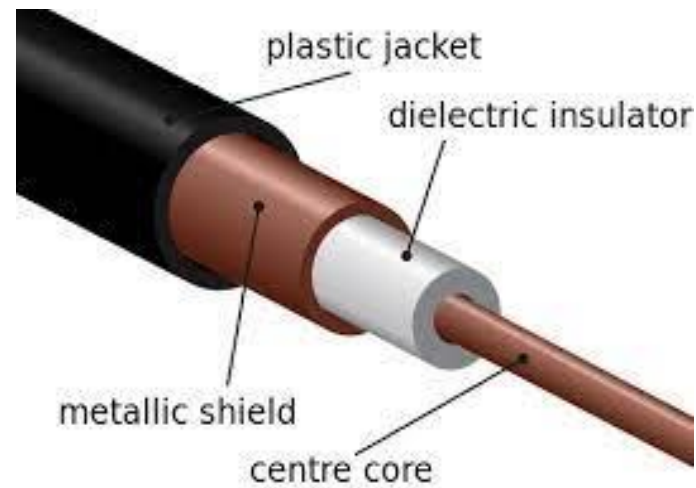
Baseband vs Broadband Coaxial Cable

- **Baseband coaxial cable**
  - —Transmitt a single signal at high speed.
- **Broadband coaxial cable**
  - —transmitting multiple signals simultaneously
  - —As in cable TV systems
  - —Analog signals at radio frequencies
  - —Expensive, hard to install and maintain

Optical Fiber Cable

- Fibre optic is a cable that holds the optical fibres coated in plastic that are used to send the data by pulses of light.
- The plastic coating protects the optical fibres from heat, cold, electromagnetic interference from other types of wiring.
  - Expensive
  - High skill needed to install and maintain
  - Faster speed
  - Longer distances
  - Better reliability
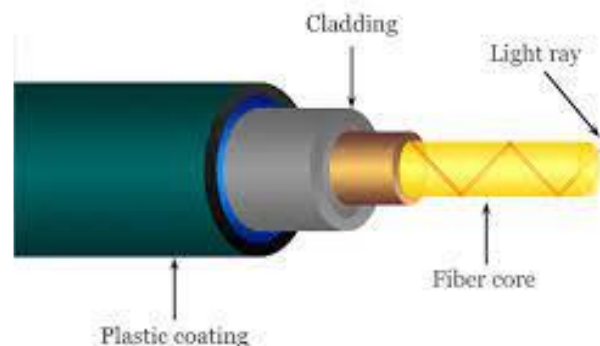
Choice of Medium

- Constrained by LAN topology
- Capacity
- Reliability
- Types of data supported
- Environmental scope

Network Devices

- Networking devices serve the following general purposes:
  - —Facilitate data transmission and communication between devices
  - —Enable efficient and secure network connectivity
  - —Enhance network performance and optimize traffic flow
  - —Provide network security
  - —Simplify network management and configuration
  - —Extend network coverage and overcome signal limitations

Repeater

- A repeater operates at the physical layer.

- Its job is to regenerate the signal over the same network before the signal becomes too weak or corrupted to extend the length to which the signal can be transmitted over the same network.

- An important point to be noted about repeaters is that they not only amplify the signal but also regenerate it.

- It is a 2-port device.

Hubs

- Active central element of star layout
- Each station connected to hub by two lines
  — Transmit and receive
- Hub acts as a repeater
- When single station transmits, hub repeats signal on outgoing line to each station
- Line consists of two unshielded twisted pairs
- Limited to about 100 m
  — High data rate and poor transmission qualities of UTP
- Optical fiber may be used
  — Max about 500 m
- Physically star, logically bus
- Transmission from any station received by all other stations
- If two stations transmit at the same time, collision

Hub Types

- **Active Hub:-** It clean, boost, and relay the signal along with the network. It serves both as a repeater as well as a wiring center. These are used to extend the maximum distance between nodes.

- **Passive Hub:-** These hubs relay signals onto the network without cleaning and boosting them and can't be used to extend the distance between nodes.

Two Level Star Topology
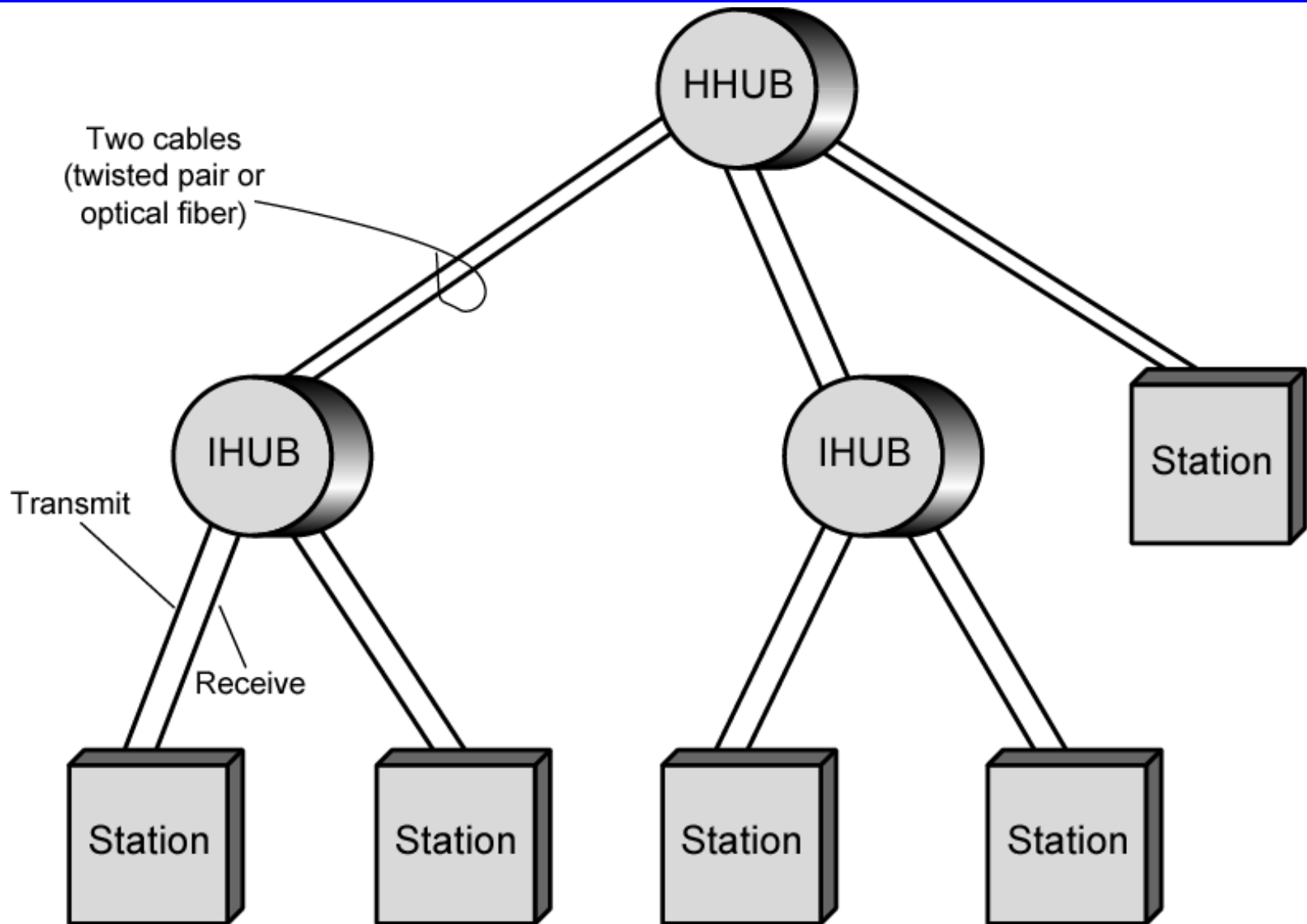
Bridge

- A bridge operates at the data link layer.

- A bridge is a repeater, with add on the functionality of filtering content by reading the MAC addresses of the source and destination.

- It is also used for interconnecting two LANs working on the same protocol.

- It has a single input and single output port, thus making it a 2 port device.

Functions of a Bridge

- Read all frames transmitted on one LAN and accept those address to any station on the other LAN

- Using MAC protocol for second LAN, retransmit each frame

- Do the same the other way round

Bridge Operation

LAN A

Station 1   Station 2   • • •   Station 10

Frames with addresses 11 through 20 are accepted and repeated on LAN B

Frames with addresses 1 through 10 are accepted and repeated on LAN A

LAN B

Station 11   Station 12   • • •   Station 20
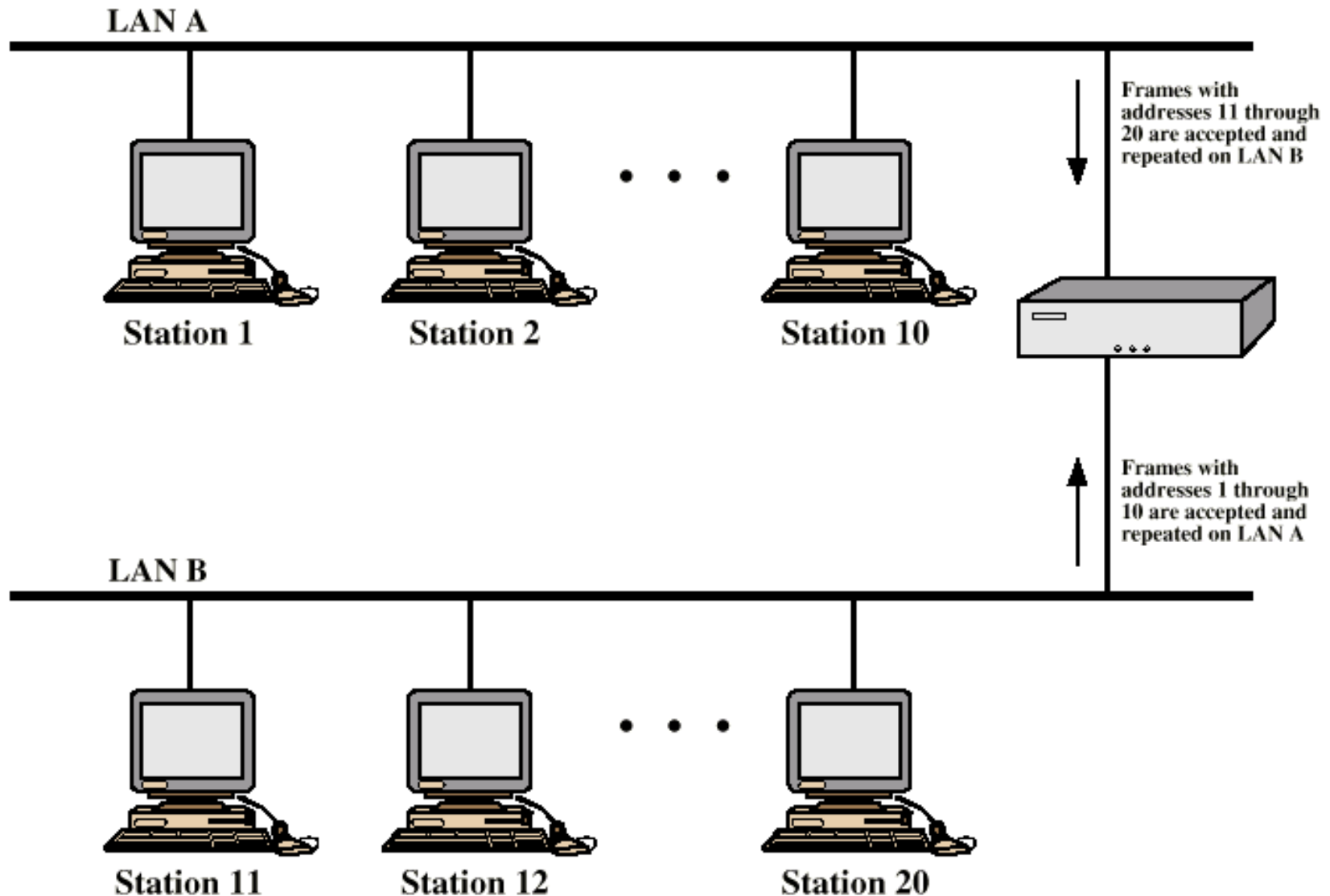
Switch

- A switch is a multiport bridge with a buffer and additional intelligence.

- A switch is a data link layer device.

- The switch can perform error checking before forwarding data, which makes it very efficient as it does not forward packets that have errors and forward good packets selectively to the correct port only.

Types

- **Unmanaged switches:** These switches have a simple plug-and-play design and do not offer advanced configuration options. They are suitable for small networks.

- **Managed switches:** These switches offer advanced configuration options such as VLANs, QoS, and link aggregation. They are suitable for larger, more complex networks and allow for centralized management.

Types

- **PoE switches:** These switches have Power over Ethernet capabilities, which allows them to supply power to network devices over the same cable that carries data.

- **Layer 2 switches:** These switches operate at the Data Link layer and are responsible for forwarding data between devices on the same network segment.

- **Layer 3 switches:** These switches operate at the Network layer and can route data between different network segments. They are more advanced than Layer 2 switches and are often used in larger, more complex networks.

Routers

- A router is a device like a switch that routes data packets based on their IP addresses.

- The router is mainly a Network Layer device.

- Routers normally connect LANs and WANs and have a dynamically updating routing table based on which they make decisions on routing the data packets.

Gateway

- A gateway, as the name suggests, is a passage to connect two networks that may work upon different networking models.

- They work as messenger agents that take data from one system, interpret it, and transfer it to another system.

- Gateways are also called protocol converters and can operate at any network layer.

- Gateways are generally more complex than switches or routers.

- A gateway is also called a protocol converter.